The Hemodynamic Effects of Timing on the Performance of the IABP: Numerical, in vitro and in vivo evaluation

Stéphanie Schampaert, Marcel Rutten, Marcel van ‘t Veer, Nico Pijls, Frans van de Vosse

Aim

The aimed effects of conventional intra aortic balloon pump (IABP) (figure 1) therapy are achieved by rapid balloon inflation, immediately after ejection, and deflation has to be completed just before aortic valve opening. However, a thorough description of the physiological effects of IABP timing is still lacking. Therefore, the goal of this study was to evaluate the support capabilities of the IABP as function of the moment of inflation and deflation in order to enhance the efficiency of the pump.

Methods

IABP evaluation was performed in three circulation models all featuring a complete systemic, pulmonary and coronary vascular bed: Lumped parameter model (numerical), model-controlled mock circulation (in vitro) and patients undergoing IABP therapy (in vivo).

The moment of balloon inflation and deflation were subsequently varied around their conventional timing modes (figure 2), and the support capabilities of the IABP in terms of cardiac output, coronary flow, cardiac stroke work and mean aortic pressure were evaluated.

Results

In all models, the evaluated hemodynamic parameters benefited the most when balloon inflation occurred a little earlier compared to the conventional timing mode, so at the end of ejection (figure 3). Slightly later deflation, such that the balloon was deflated simultaneously with ejection, resulted in maximum benefits for the systemic circulation (figure 3).

Conclusion

Timing is an important tool for optimizing IABP support. Early inflation unconditionally interferes with ejection. Late inflation leads to sub-optimal coronary perfusion, just as early deflation. In addition, early deflation results in a sub-optimal afterload reduction, while for extremely late deflation the afterload reduction is essentially absent.

So in conclusion, the efficiency of IABP therapy may be enhanced by earlier balloon inflation and later balloon deflation in comparison to the conventional IABP timing mode.